Department of Mechanical Engineering

National Institute of Technology Raipur

(Institute of National Importance)

G. E. Road, Raipur-492010 (CG)

B.Tech. in Mechanical Engineering
Fifth Semester Scheme

Sl. No.	Course Title	Course Name	L	T	P	Credits
1.	Program Core (CXX52) ME105101ME	Heat and Mass Transfer	3	1	0	4
2.	Program Core (CXX53) ME105102ME	Refrigeration and Air Conditioning	3	1	0	4
3.	Program Core (CXX54) ME105103ME	Machine Design - 1	3	1	0	4
4.	Program Elective (EXX1) ME10520XME		3	0	0	3
5.	Program Elective (EXX2) ME10521XME		3	0	0	3
6.	Open Elective (OXX1) ME10530XME		3	0	0	3
7.	Laboratory	Mechanical Lab - 5	0	0	2	1
8.	Laboratory	Mechanical Lab - 6	0	0	2	1
9.	Summer Internship 1					1
			18	**3**	**4**	**24**

Department of Mechanical Engineering

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List of Program Electives (EXX1)		
Sl. No.	**Code**	**Course Name**
1.	ME105201ME	**Dynamics and Vibration**
2.	ME105202ME	**Industrial Engineering & Management**
3.	ME105203ME	**Introduction to Aerospace Engineering**
List of Program Electives (EXX2)		
1.	ME105211ME	**Design and Optimization of Energy systems**
2.	ME105212ME	**Measurement and Control**

List of Open Electives (OXX1)		
Sl. No.	**Code**	**Course Name**
1.	ME105301ME	**Computational Fluid Dynamics**
2.	ME105302ME	**Composite Materials and Mechanics**
3.	ME105303ME	**Finite Element Method**

Department of Mechanical Engineering

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G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Dynamics and Vibration**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Program Elective**
7.	Pre-requisites (course no./title)	Physics, Engineering Mechanics and Kinematics of Machines
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 1. Apply the concepts of Newtonian and Lagrangian Mechanics in deriving the Equation of Motion of a Discrete System. 2. Model an Equivalent Single Degree of Freedom (**SDOF**) System and Analyze 3. the characteristics. 4. Understand the concept of Eigen values and Eigen vectors in the context of Multi-Degree of Freedom (**MDOF**) system and predict the motion characteristics of the same. 5. Get a preliminary understanding of the Dynamics of Rotors and the Vibration responses of continuous systems.	
10.	**Course Syllabus** **UNIT I - Review of Dynamics** Review of Newtonian Mechanics, Dynamics of Rigid Bodies. Degrees of Freedom and Generalized Coordinates, Coordinate Systems (Cartesian, Polar, Cylindrical and Spherical coordinate Systems), Velocity and Acceleration in different coordinate systems, Velocity and Acceleration in different frames of references. Constraints and Types of Constraints. **Introduction to Analytical Dynamics**: Lagrangian and Hamiltonian Dynamics, Conservative Force Fields Euler- Lagrange Equation of Motion, Deriving the Equation of Motion of the given system, Variational Approach, Extended Hamilton's Dynamics, Introduction to Rayleigh Dissipation Function. Coordinate Coupling. **UNIT II – Single Degree of Freedom (SDOF) System** Response of first order and second order systems, Free vibration of **SDOF** Spring mass system, Introduction to Harmonic oscillator, Solution to the **SDOF** Spring Mass system, Introduction to Damping, types of damping (Viscous, Coulomb and Quadratic Damping models), Response of **SDOF** Spring Mass and Damper System, Nature of Damped System (underdamping, Critical damping and Over damping). Solution to the Equation of motion of **SDOF** spring mass and damper system. Forced response of **SDOF** spring mass system, Response of system to periodic forcing, impulse forcing and step forcing. Forced response of **SDOF** spring mass and damper	

	system, Response to rotating Imbalance problem, base excitation, and shock. Single cylinder engine vibration analysis. **UNIT III – Multi-degree of Freedom (MDOF) System** Concept of Eigen Values and Eigen vectors, Eigen Frequencies, modelling a **CO_2** molecule for Stretch as **MDOF** system, Principle of Orthogonality of Eigen values, Coordinate coupling, Solution to Equation of motion of **MDOF** Spring Mass Damper System. Response of two degree of freedom system under harmonic excitation, Modal Analysis. **Vibration Absorber:** Concept of Undamped Vibration Absorber, Tuned Mass Damper, Dynamic Vibration absorber, modelling a **MDOF** system consisting of Rotor imbalance, Forced Response of **MDOF** System **UNIT IV – Dynamics of Rotors and Vibration of Continuous Systems** **Dynamics of Rotors:** Whirling Speed, Critical Speed, Vibration response of Eccentrically mounted Rotors, Response of Rotors modelled as Vibrating System. **Vibration of Continuous systems:** Introduction to continuous systems, Axial Vibration of Bars and Bending Vibration of Beams and Bars, Orthogonality of Natural Modes, Expansion Theorem, Rayleigh ritz method, Rayleigh's Quotient, Introduction to vibration of plates and Shells.
11.	**Text Books-** 1. **Engineering Dynamics**, J H Ginsberg, Cambridge University Press. 2. **Elements of Vibration Analysis**, Leonard Meirovitch, Tata McGraw Hill.
12.	**Reference Books-** 1. **Advanced Dynamics**, J H Ginsberg, Cambridge University Press. 2. **Mechanical Vibration**, S. S. Rao, Addison Wesley Publishes 2nd Edition. 3. **Vibration and Waves in Continuous Mechanical Systems**, Peter Hagedorn and Anirvan DasGupta, Wiley Publishers.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Industrial Engineering & Management**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Program Elective**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** The course is intended to provide the concepts, knowledge, objectives, functions, contributions and place of industrial engineering and management to the students, so that students will be able to 6. Provide strategic decisions regarding location, site selection, plant layout and line balancing for the industries. 7. Understand the concept of work study, method study, work measurement and able to provide the solution in this regard for the industries. 8. Recognize the need and furnish the solutions of maintenance, replacement policies and inventory planning issues for the business organization. 9. Identify, formulate, and solve the managerial problems of the design, planning, control, and improvement of both manufacturing and service operations.	
10.	**Course Syllabus** **UNIT I - Introduction:** Definition of Industrial engineering, History & development, Objective of Industrial Engineering, Function of Industrial engineer, Definition of Management, System approach to Management, Social responsibility, ethics and management, Functions of Management, Nature and purpose of organizing, Formal and informal organization, Types of organizational structure and their selection. **UNIT II –Location, Layout, Line balancing & Work Measurement:** Facility Location and Layout: Need for a suitable location, Factors affecting location, Quantitative method for evaluation of plant location, Objectives & Principles of plant layout, Types of layout and their suitability, Line balancing concepts, Line balancing techniques, Work Study, Method Study & Work Measurement: Productivity, Definitions, Recording techniques, Flow Process Charts, man-machine chart, Motion economy principles, Micro motion study – Therbligs, Work measurement techniques, Rating, Allowances, Normal and standard time determination, Work sampling. **UNIT III –Maintenance Management and Inventory Planning & Control:** System Objectives and need for maintenance, Types of maintenance, Breakdown, Predictive and Preventive Maintenance, Condition based maintenance system, reliability,	

	Work study for Maintenance, Total Productive Maintenance (TPM), Equipment replacement policy: Overhaul and Replacement, Reasons for replacement, Deterioration, Obsolescence, Depreciation, Methods for depreciation calculation, Inventory Control: Scope, purchasing and storing, economic lot size, ABC analysis. **UNIT IV –Production Planning & Control:** Functions, Sequencing, forecasting, routing, Product selection & Process selection, Production Control: Gantt chart, work order, CPM and PERT techniques. Inspection and Quality control: Types of inspections, statistical quality control; Control charts for variables and attributes: X bar, R, p and c charts; Sampling, concepts and scope of TQM and QFD
11.	**Text Books-** 3. **Essential of Management**- H. Koonz and H. Weihrich, McGraw-Hill. 4. **Modern Production / Operations Management**- Buffa, E.S., and Sarin, R.K., John Wiley & Sons. 5. **Industrial Engineering and Production Management**- Martand Telsang, S Chand & Company. 6. **Industrial Engineering Handbook**- Maynard, H.B., McGraw-Hill.
12.	**Reference Books-** 1. **Industrial Engineering & Management–A new perspective**, Philip E Hicks, McGraw-Hill. 2. **Comprehensive Industrial Engineering**- N. J. Manek, Laxmi Publications. 3. **Industrial Engineering and Management Systems –** S. Dalela, Mansoor Ali, Standard Pub.

Department of Mechanical Engineering

National Institute of Technology Raipur

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G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Introduction to Aerospace Engineering**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Program Elective**
7.	Pre-requisites (course no./title)	Nil
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 10. Demonstrate knowledge on evolution of plates, functioning of different components, role of regulatory and authorities and safety aspects of flight. 11. Gain knowledge on aerodynamic behaviour of rigid curved surfaces and their significance in controlling flight 12. Exercise good command on structured anatomy and strength aspects of different components of aircraft. 13. Identify different types of engines that suit the needs of different aerospace vehicles 14. Exhibit the science of flying an aerospace vehicle and controlling of crucial subsystems that make a full-fledged flight.	
10.	**Course Syllabus** **UNIT I – Introduction** Introduction Evolution of planes, pre-Wright brother era to present plane, progress in structure airplane design and applications, classification of aircrafts and space vehicles, functions of major components of an airplane, conventional control and power controls, role of DGCA in air safety and regulatory authority, accident investigation, human factors in flight safety, Introduction to FAA **UNIT II** Basic Aerodynamics Aerospace atmosphere, types, characteristics, pressure, temperature and density variations, lapse rate, airfoil nomenclature, forces acting on airfoil, characteristics of airfoils. Flight Control Surfaces: Aircraft principle axes, main control surfaces- ailerons, elevators, rudders, spoilers and flaps, use of flaps during takeoff, landing and maneuvering. **UNIT III** Structures Structural arrangement of monocoque and semi-monocoque structures, geodesic construction. Structural layout of wing, fuselage and tail plane, types of wings,	

	monoplanes, biplanes, triplanes and multiplanes, wing geometry - different types and purpose. **UNIT IV** Propulsion Piston engines and gas turbine engines, various means of thrust production, comparative merits. Ramjet, pulse jet and scramjet. Rockets - principle of operation, types and applications. Helicopters: Rotorcraft, types of rotorcraft, autogyro, gyrodyne. Helicopters, main rotor system, fully articulated, semi rigid and rigid rotor system, transmission system.
11.	**Text Books-** 7. **Introduction to Flight,** J. D. Anderson, 6/e, McGraw Hill,2010. 8. **Fundamentals of Flight,** R. S. Shevell, 2/e, Pearson, 2004.
12.	**Reference Books-** 4. **Flight Without Formulae,** A.C. Kermode, 5/e, Pearson, 1989. 5. **Helicopter Engineering,** L. Gupta, Himalayan Books, 1996. 6. **Interactive Aerospace Engineering and Design,** D. Newman, McGraw Hill, 2002. 7. **Aircraft Flight,** R. H. Barnard and D. R. Philpot, 3/e, Pearson, 2004.

Department of Mechanical Engineering

National Institute of Technology Raipur

(Institute of National Importance)

G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Design and Optimization of Energy systems**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Program Elective**
7.	Pre-requisites (course no./title)	Thermodynamics, Fluid Mechanics, Numerical Techniques
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 15. Understand the procedure of Designing the Energy System 16. Estimate the design cost of the propose system. 17. Model and simulate the Thermal System 18. Apply different optimization Techniques for suggesting the suitable Energy Systems.	
10.	**Course Syllabus** **UNIT I – Introduction** Introduction to design and specifically system design, Morphology of design with a flow chart, very brief discussion on market analysis, profit, time value of money, an example of discounted cash flow technique., Concept of workable design, practical example on workable system and optimal design. **UNIT II – System Simulation** Classification, Newton Raphson method-one unknown, Newton Raphson method, Gauss Seidel method, Data Analysis, Rudiments of finite difference method for partial differential equations with an example. **UNIT III - Single Variable Optimization** Introduction, Formulation of optimization problems, Calculus techniques- Search methods-Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, Fibonacci search and Golden section search method. **UNIT IV - Multi Variable Optimization** Evolutionary Optimization Method, Cauchy's steepest descent method. Lagrangian multiplier method for constrained/unconstrained optimization, Linear programming-two variable problem-graphical solution, Modern optimization techniques	
11.	**Text Books-**	

	9. **Essentials of Thermal System Design and Optimization,** C. Balaji, Ane Books. New Delhi in India and CRC Press in the rest of the world.
12.	**Reference Books-** 8. **Design and optimization of thermal systems,** Y.Jaluria, Mc Graw Hill, 1998. 9. **Elements of thermal fluid system design,** L.C.Burmeister, Prentice Hall, 1998. 10. **Design of thermal systems**, W.F.Stoecker, Mc Graw Hill, 1989. 11. **Introduction to optimum design,** J.S.Arora, Mc Graw Hill, 1989. 12. **Optimization for engineering design - algorithms and examples,** K. Deb, Prentice Hall, 1995.

Department of Mechanical Engineering

National Institute of Technology Raipur

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G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Measurement and Control**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Program Elective**
7.	Pre-requisites (course no./title)	Basic Electrical and Mechanical Engineering, Engineering Mechanics, Engineering Drawing
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 19. To understand the characteristics, functioning and calibrations of various measuring instruments. 20. To understand the use of instruments for measuring displacement, velocity, pressure, and temperature. 21. To understand the working of strain gauges and their use for measuring force and torque. 22. To understand the use of instruments for measuring flow rate, noise, and vibrations. 23. To understand the data acquisition system for enhancing the productivity 24. To understand the surface characteristics and their measurement using mechanical and optical instruments.	
10.	**Course Syllabus** **Unit-I** **Generalized Measurement System:** Definition, application of measurement instrumentation, functional elements of a generalized measuring system, measuring standards, types of measurement, types of input to measuring instruments and instrument system, classification of measuring instruments, merits and demerits of mechanical measuring systems, Errors: Introduction to error, types of error, Sources of error, Sensor and Transducers- Types of sensor and Transducers and their characteristics. **Static and Dynamic characteristics of Instruments** Introduction, Static characteristics: accuracy, error and correction, calibrations, precision, resolution, static sensitivity, linearity, hysteresis, dead zone, backlash, and drift, Selection of measuring instruments, Mechanical and Electrical loading. Transient and steady state analysis of Zero, first and second order system. Time Domain specifications. Step response of second order system. Steady-state error, error	

	coefficients, steady state analysis of different type of systems using step, ramp, and parabolic inputs. **Unit-II** **Displacement Measurement**: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer **Strain Measurement**: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge-based load cells and torque sensors **Measurement of Angular Velocity:** Tachometers, Tachogenerators, Digital tachometers and Stroboscopic Methods. **Acceleration Measurement**: Theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers. **Measurement of flow**: Obstruction meters, Variable head meters, Hot wire and magnetic meters, Ultrasonic flow meters. Vibration and noise measurement: Seismic instruments, Vibration pickups and decibel meters. **Unit-III** **Metrology:** Linear and angular measurement devices and systems limit gauges, Gauge blocks. Measurement of geometric forms like straightness, Flatness, Roundness and Circularity, principles and application of optical projectors, Microscope, Autocollimators etc. Principle and use of interferometers, Comparators, Measurement of screw threads and gears, Surface texture measurement. **Data acquisition system:** Introduction to data acquisition systems, Single and multichannel systems, Microprocessors and PC based data acquisition systems. Input – output devices signal transmission and Processing, Devices, and systems. **Unit-IV** **Control:** Introduction to control systems, Classification of control system. Open loop and closed loop systems. Mathematical modeling of control systems, concept of transfer function, Block diagram algebra. **Stability analysis**: Introduction to concepts of stability, The Routh criteria for stability, Experimental determination of frequency response, Stability analysis using Root locus, Bode plot and Nyquist Plots, State space modeling, Process control systems, ON-OFF control. P-I-D Control.
11.	**Text Books-** 10. **Measurement Systems, Application and Design** – E.O. Doebelin - McGraw Hill 11. **Mechanical Measurements and Control** – D.S. Kumar – S.K. Kataria & Sons 12. **Mechanical Measurements** – G. Beckwith &Thomas G. – Pearson Education 13. **Experimental Methods for Engineers** - J. P. Holman. - McGraw Hills Int. Edition 14. **Instrumentation & Mechanical Measurements** - A.K. Thayal.
12.	**Reference Books-** 13. **Engineering Metrology** – K.J. Hume - MacDonald and Company 14. **Engineering Metrology** – I.C. Gupta - Dhanpat Rai & Sons 15. **Mechanical & Industrial Measurements** – R.K. Jain – Khanna Publishers 16. **Mechanical Engineering Measurements** - A. K. Sawhney – Dhanpat Rai& Sons, New Delhi.

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National Institute of Technology Raipur

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G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Computational Fluid Dynamics**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Open Elective**
7.	Pre-requisites (course no./title)	Basic course in Fluid Mechanics
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 25. Equip the students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems. 26. Define and setup flow problem properly within CFD context. 27. Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution; 28. Use CFD software to model relevant engineering flow problems, analyze the CFD results. Compare with available data and discuss the findings.	
10.	**Course Syllabus** **UNIT I - MATHEMATICAL MODELLING OF FLUID FLOW** Conservation laws & governing equations for fluid flow: Continuity equation, Momentum equation etc. and their derivations, General form of conservation equations, Boundary conditions, Classification of equations, Mathematical modeling practices of basic fluid flow problems and its solution, Methods of flow visualization. **UNIT II - METHODS OF DISCRETIZATION** Introduction to Computational methods, Components and properties of computational methods, Various methods of discretization; Illustration of Finite volume method (FVM) for generalized form of conservation equations, Solution of steady & unsteady diffusion equations, Solution of convection-diffusion equation with illustration of various differencing schemes. **UNIT III - SOLUTION OF LAMINAR FLOW PROBLEMS** Basic equations for Laminar flow cases, Calculation of flow field variables, Difficulties involved in solution of momentum equations, Staggard grid, Navier-Stokes solvers, SIMPLE algorithm & its variants, Solution of simple viscous laminar flow problems as Couette flow, Poiseuille flow, boundary layer flows, etc., Implementation of various boundary conditions, Numerical techniques for solution of algebraic equations. **UNIT IV - (A) INTRODUCTORY SOLUTION OF TURBULENT FLOW PROBLEMS** Important features of turbulent flow, Reynolds average Navier-stoke (RANS) equation, Necessity of turbulence modeling, Different types of turbulence model, Illustrative	

	example and practice. **(B) ERRORS AND POST-PROCESSING OF CFD** Error estimation in computational method, Mesh independent study, validation of CFD results, Post processing of results, Reporting and Documentation of CFD results, Graphic techniques used in CFD, Guidelines for CFD practices, Benchmark problems.
11.	**Text Books-** 15. **An Introduction to Computational Fluid Dynamics: The finite volume Method,** Versteeg, H.K., and Malalasekera, W. 16. **Computational fluid dynamics – The basics with applications,** Anderson, J.D. 17. **Computational Methods for Fluid dynamics,** Ferziger and Peric.
12.	**Reference Books-** 17. **Numerical heat transfer and fluid flow**, Patankar, S. V., Hemisphere Publishing Corporation, 2004. 18. **Turbulent flows,** Pope S. B., Cambridge university press. 19. **Computer simulation of flow and heat transfer,** Ghoshdastidar, P. S., Tata McGraw Hill Publishing Company Ltd., 1998.

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National Institute of Technology Raipur

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G. E. Road, Raipur-492010 (CG)

Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Composite Materials and Mechanics**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Open Elective**
7.	Pre-requisites (course no./title)	Mechanics of Solids, Material Science
8.	Frequency of offer	Once per Academic Year
9.	**Course Objectives (CO):** At the end of this course, the students will be able to 29. Discuss the benefits and disadvantages of using composites in aerospace and other applications 30. To identify the properties of different materials (fibres, resins, cores) used in composites, select the most appropriate manufacturing process for fabricating composite components 31. To predict the elastic properties of both long and short fibre composites based on the constituent properties. 32. Calculate the elastic and strength properties of unidirectional laminates using micromechanics theory 33. To apply failure criteria and critically evaluate the results of the failure strength of a laminated composite plate. 34. Get knowledge on issues in fracture of composites and environmental degradation of composites	
10.	**Course Syllabus** **UNIT I** Basic concepts and characteristics, Geometric and Physical definitions, natural and man-made composites, applications, types and classification of composites. Reinforcements, Particulate composites, Polymer composites, Thermoplastics, Metal matrix and ceramic composites. **UNIT II** Characterization of composite properties. Manufacturing methods. Micromechanics, Unidirectional composites, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations. **UNIT III** Coordinate transformation, Hooke's law for two dimensional unidirectional lamina, Transformation of stress and strain, Numerical examples of stress strain transformation, Graphic interpretation of stress-strain relations. Elastic behaviour of unidirectional	

	composites, relationship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations. **UNIT IV** Failure mechanics. Application of composite materials in different areas of engineering with case studies.
11.	**Text Books-** 18. **Mechanics of Composite Materials,** R. M. Jones, McGraw Hill. 19. **Mechanics of Composite Materials,** Autar K. Kaw, CRC
12.	**Reference Books-** 20. **Advanced Mechanics of Composite Materials,** Vasiliev and Morozov, Elsevier.

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Semester-V

1.	Department proposing the course	**Mechanical Engineering**
2.	Course Title	**Finite Element Method**
3.	L-T-P Structure	**3-0-0**
4.	Credits / # of period	3
5.	Course Number (Code)	
6.	Status (Core/Elective)	**Open Elective**
7.	Pre-requisites (course no./title)	Mathematics (I, II and III), Numerical Methods, Mechanics of Solids and Fluids
8.	Frequency of offer	Once per Academic Year
9.	**Course Introduction and Objective:** Finite Element Method (FEM) is widely used in industry for analyzing and modelling structures and continua, whose physical behaviour is described by ordinary and partial differential equations. The subject is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods. The main objective of this course is to introduce the mathematical concepts of FEM for obtaining an approximate solution of ordinary and partial differential equations. Fundamentals of the Finite Element Method covering Methods of Weighted Residuals, Weak formulation, Elements and their shape functions and application of these in problems from all domains of Computational Mechanics will be covered. Being offered as an open elective, the course will cover applications from Mechanical, Civil, Chemical and Bio-Mechanical engineering domains. The learning process will be enhanced by completing assignments using software and libraries such as OCTAVE/MATLAB, FREEFEM++, FENICS, AGROS2D, ELMER MP, CALCULIX and ANSYS. **Course Outcomes:** This course will develop the technical competence capability and at the conclusion of this course, students should be able to demonstrate: 1. Knowledge of the concepts, mathematical formulation and numerical implementation of FEM. 2. Knowledge of the FEM as applied to solid mechanics, fluid mechanics and heat transfer problems. 3. The ability to invoke appropriate assumptions, select proper elements and develop and validate a Finite Element model using a range of techniques. 4. Application of complex problem-solving using Software/libraries. Be able to communicate effectively in reporting (both textually and graphically) the method used, the implementation and the numerical results obtained.	
10.	**Course Syllabus** **UNIT I – A. Introduction and Approximations**	

	Introduction to Finite Element Method, Discretization, Methods of weighted residual, Strong and weak forms for 1D and 2D problems. **B. Elements and their shape functions** Global, local and natural coordinates, shape functions and their properties, Lagrange interpolation-, one-, two- and three-dimensional elements, Serendipity elements, h-p elements, isoparametric elements. **UNIT II - Direct Formulation** Principle of Minimum Potential Energy, Direct approach, element and assembly stiffness, treatment of boundary conditions, bar, truss, beam and frame elements, Gauss-Legendre's quadrature. **UNIT III - Energy Principle based formulation** Constitutive and compatibility relations, Finite element formulation for plane stress, plane strain and axisymmetric problem. Work equivalence, structural formulation using CST and isoparametric elements. **UNIT IV Scalar field problem and Dynamics** One- and two-dimensional formulation of Scalar field problems, Application to in-viscid and viscid flows, heat transfer, analogous problems of torsion. Hamilton's Principle, Lagrange's equation, lumped and consistent mass matrices.
11.	**Text Books-** 20. **Text Book of Finite Element Analysis,** P. Seshu, PHI Learning Pvt. Ltd., 2003.
12.	**Reference Books-** 1. **Concepts and Analysis of Finite Element Applications,** R. D. Cook, D. S. Malkus, M. E. Plesha and R. J. Witt, John Wiley & Sons, 1981. 2. **An introduction to the Finite Element Method,** J.N. Reddy, McGraw- Hill, 2006. 3. **A First Course in the Finite Element Method,** Daryl L. Logan, Cengage Learning, 2011. 4. **Finite Element Analysis: Theory and Application with ANSYS,** Saeed Moaveni, Pearson Education.